5.—The petrology and archaeological significance of mylonitic rocks in the Precambrian shield near Perth, Western Australia

by J. E. Glover[1]

Manuscript received 18 November 1975; accepted 15 December 1975

Abstract

Mylonitic rock from shear zones in Archaean granitoids on the western margin of the Yilgarn Block, near Perth, Western Australia, has been used extensively for flaked tools by Aborigines. The rock is epidote-rich and flinty, with quartz veinlets, and commonly has a subconchoidal fracture.

Flakes are found in the Perth Basin between Eneabba and Mandurah. They are common at eastern sites near the mylonitic zones, but are sparse or absent near the west coast.

Introduction

The duration of Aboriginal occupation in Australia exceeds 32 000 years (Barbetti and Allen, 1972), and workers from the Western Australian Museum have provided evidence of occupation in southwestern Australia of at least 25 000 years (Dortch and Merrilees, 1973). Localities strewn with their artifacts are numerous in the southwest (Hallam 1972, Glover 1975).

Outcrop in the central Perth Basin (*i.e.* that part of the basin between Eneabba and Mandurah) is sparse, and most of the rock is limestone or sandstone, which is unsuitable for flaking. Artifacts in the area have generally been made from quartzite, quartz, silcrete, granite and dolerite, which have been carried westward from the Yilgarn Block, or from bryozoan chert which may have been carried eastward from quarries now covered by the Indian Ocean. Eastern sites are dominated by quartzite flakes, but bryozoan chert tends to become increasingly important toward the west. One rock represented at many localities, and referred to previously as green non-fossiliferous chert (Hallam 1972; 1974) or veined epidote-bearing chert (Glover 1975) has been an enigma, for both its provenance and petrology have been speculative. Outcrops of the parent rock have now been identified as mylonite and altered mylonite in shear zones on the western part of the Yilgarn Block, and confirm earlier suggestions that the flakes were of Precambrian rock derived from the east. This note is concerned with the description of the cherty epidote-bearing flakes and their distribution, and with the nomenclature and petrology of their parent rock.

The colours and corresponding numerical designations used below refer to the Rock-color chart distributed by the Geological Society of America (Rock-color Chart Committee 1963).

[1] Geology Department, University of Western Australia, Nedlands, Western Australia, 6009.

The flakes

Appearance and typology

The flakes of cherty epidote-bearing rock range considerably in size, but many of them have a maximum dimension of about 3 cm. The Aborigines seem to have preferred this kind of rock for making small flat adzes and backed blades (see Hallam 1974, p. 83). The rock generally breaks with subconchoidal fracture, and consists of small disseminated quartz and feldspar grains (porphyroclasts) in an aphanitic groundmass of silica and epidote granules. Many flakes are cut by thin quartz veins and minute faults. Flakes are commonly light greenish grey (5GY8/1), pale greenish yellow (1OY8/2), or pale olive (1OY6/2), and where they have been stained or bleached in surrounding soil or sand, they generally retain a greenish cast because of their epidote content.

Distribution in the Perth Basin

Cherty epidote-bearing flakes have been found at 31 sites in or just outside the eastern margin of the Perth Basin between Eneabba in the north and Mandurah in the south, a distance of about 300 km (see Fig 1). The sites are commercial sandpits or sandy areas in which the artifacts have been concentrated by deflation of sand. Although widespread, the cherty epidote-bearing flakes are generally not abundant at artifact localities in the central Perth Basin: they are absent from 13 sites, and form less than 1% of the flake population at 18 sites (see Table 1). Sites near the west coast are without exception low in these flakes, but higher proportions (8-39%) are found near the eastern margin of the basin, in the Gingin-Bullsbrook-Walyunga area. It should be borne in mind that the proportion of any one rock type in flakes found on the surface of a wind-deflated area depends on many factors, including the history of human occupation at the site, the depth of erosion, the availability of the particular rock type, the rock's suitability in the light of typological changes, its durability, and its distance from the source. The last-mentioned factor seems to have been the most significant here, for the distribution north of the Swan River accords well with a mylonitic source in the Walyunga region, where there are numerous outcrops of mylonite.

The mylonitic rocks

Outcrop distribution

Mylonite and blastomylonite have been recorded by Wilde (1974) in Archaean granitoid of the Walyunga area, and in the Chittering Metamorphic Belt at Mogumber, about 130 km

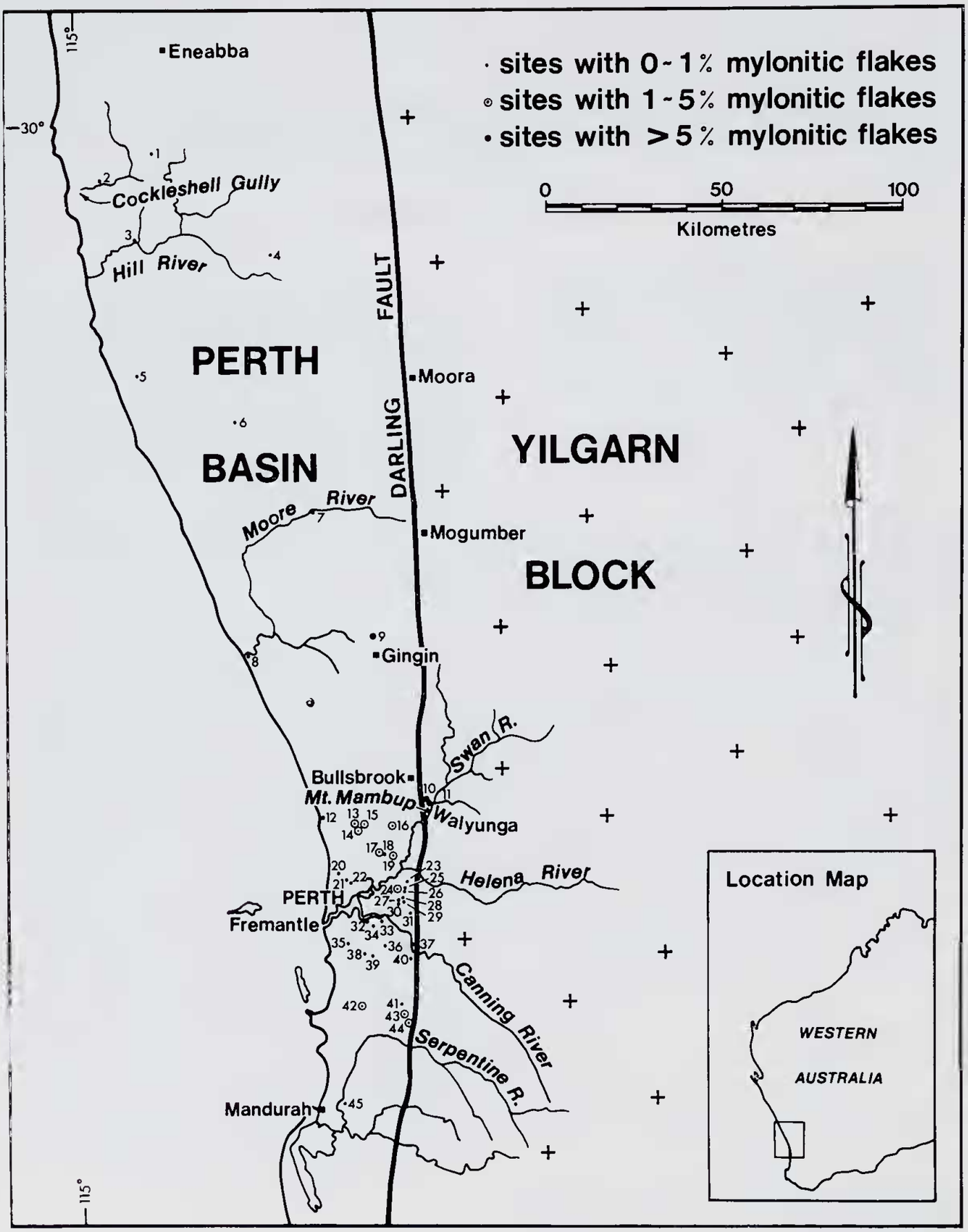


Figure 1.—Map of the central Perth Basin, showing location of artifact sites described in Table 1.

Table 1

Proportion of flakes of mylonitic rock at sites in the central Perth Basin. Sites were located on 1 : 250 000 Series R 502 maps, and co-ordinates are based on grid references estimated to the nearest hundredth. Co-ordinates refer to centre points of large sites.

Site No.	Type of site	Map	Map co-ordinates	Flakes counted	Percent mylonitic rock
1	Road cutting in sand, Kooringa area	SH50–9	32002760	319	0
2	Sandy soil, N bank Cockleshell Gully	SH50–9	30372666	215	0
3	Sand blow-out N bank Hill River	SH 50–9	31492481	310	0
4	Sand spoil from dam about 1 km W Dinner Hill	SH50–10	35772452	154	0
5	Sand blow-outs, Pinnacles area	SH50–9	31692063	2 107	0
6	Sand near dam, Caro Station	SH50–9	34651927	249	0·4
7	Road cutting in sand, S bank Moore River, Regans Ford	SH50–10	36921652	133	0·7
8	Blow-outs in yellow sand, near mouth of Moore River	SH50–14	34851205	886	0·3
9	Sand blow-out 2 km NNW Gingin Railway Station	SH50–14	38801260	406	8·4
10	Sandy area 6 km S Bullsbrook East	SH50–14	40370758	290	39·0
11	Sandy area Walyunga National Park	SH50–14	40640743	1 624	10·7
12	Blow-outs in yellow sand, 1 km north Mullaloo Beach	SH50–14	37190695	127	0
13	Gnangara Sandpit	SH50–14	38370671	249	3·0
14	Brambles Sandpit	SH50–14	38410669	193	2·6
15	Sandy area, SW margin of L. Gnangara	SH50–14	38550680	684	1·0
16	Bell Bros Sandpit, Gnangara Road	SH50–14	39730675	309	3·3
17	Ready Mix Sandpit, Beechboro	SH50–14	39040592	307	4·2
18	Road cut in sand, Beechboro Road	SH50–14	39180588	228	0·9
19	Widgee Road Sandpit, Beechboro	SH50–14	39380584	291	2·7
20	Sand patch, S side Talbot Way, Woodlands	SH50–14	36880540	373	0
21	Sand dune, NW of L. Monger	SH50–14	38120517	344	0·3
22	Red sand, E shore of L. Monger	SH50–14	38220512	642	0·5
23	Sandpit, Maida Vale	SH50–14	39880510	347	0·3
24	Exposed sand, airport runway extension	SH50–14	39600492	348	1·4
25	Rail cutting in sand near Wittenoom Road, Maida Vale	SH50–14	39820496	353	0·2
26	Sand blow-out near Bingham Street, Maida Vale	SH50–14	39800490	384	0·2
27	Exposed sand, Kewdale	SH50–14	39550449	669	0·4
28	Sandpit, Hardey Road, Cloverdale	SH50–14	39630455	717	0·1
29	Exposed sand, Newburn Road, Kewdale	SH50–14	39690452	413	0·2
30	Sand blow-out N side Dowd Street, Kewdale	SH50–14	39550434	318	0·5
31	Sandpit NE White Street, Orange Grove	SI50–2	40140397	306	0
32	Exposed dune, corner High Road, Leach Highway, Riverton	SI50–2	38700377	378	0
33	Exposed sand, Metcalf Road, Lynwood	SI50–2	39160377	181	0·5
34	Sand blow-out, corner Riley Road, Nicol Road, Lynwood	SI50–2	38980364	317	0
35	Snashall Bros Sandpit, Bibra Lake area	SI50–2	38080308	394	0·2
36	Coopers Sandpit, Canning Vale	SI50–2	39220303	277	0·4
37	Hot Mix Sandpit, Gosnells	SI50–2	40110265	361	0·3
38	Ready Mix Sandpit, Forrest Road, Jandakot	SI50–2	38590273	299	0
39	Calsil Sandpit, Forrest Road, Jandakot	SI50–2	38780266	118	0
40	MWSS & OB Sandpit, Lilian Avenue, Armadale	SI50–2	40110266	359	0·6
41	Fremnells Sandpit, Hopkinson Road, Cardup	SI50–2	39710126	1 589	0
42	Wellard Sandpit, Parmelia	SI50–2	38540114	174	1·7
43	Sand blow-outs, Lang's Farm, Mundijong	SI50–2	39820092	500	2·5
44	Sand blow-out, 0·5 km S railway bridge, Mundijong	SI50–2	40040058	374	1·6
45	Sandpit 4·5 km E Stake Hill Bridge, Mandurah	SI50–2	38049805	116	0

to the north. The rocks are found in a NNE-trending zone. Wilde suggests that the present Darling Fault runs subparallel to an ancient zone of north to north-east shearing that may have been reactivated many times.

Mylonite is also known at Cookernup over 100 km south of the area mapped by Wilde, and is likely to crop out in intervening country.

Terminology

Two terms are commonly used for strongly coherent fine-grained rocks of shear zones, namely mylonite and cataclasite (or cataclastite). Modifications of these terms are numerous, but only the most important are considered here.

The nomenclature of cataclastically deformed rocks has recently been discussed by a large number of authors, including Christie (1960), Reed (1964), Joplin (1968), Spry (1969), Bell and Etheridge (1973) and Zeck (1974), and a confusing array of names has arisen. Even the style of deformation is now questioned, so that although most authors have assumed a predominance of brittle deformation as implied by the terms mylonite (Gr. *myle*, mill) and cataclasite (Gr. *klastos*, broken in pieces), Bell and Etheridge believe that deformation can be essentially ductile.

It is commonly held that mylonite is characterized by foliation, as indicated by Lapworth (1885) in his original definition, whereas cataclasite is said to lack foliation (see Christie 1960 Reed 1964, Spry 1969). Christie, in addition, implies that cataclasite is derived from mylonite by ultrabrecciation. On the other hand, Zeck (1974) uses the term cataclastite in a fairly wide sense for fine-grained foliated and massive rocks that have been formed by rupture and show no noteworthy recrystallization.

Cataclastic rocks whose rupture has been accompanied or followed by sufficient recrystallization or neomineralization to obscure their cataclastic nature have commonly been given names prefixed by *blasto*, e.g. blastomylonite, blastocataclasite.

In this paper, the term mylonitic rock is used to include all the varieties of strongly coherent, fine-grained rock considered above.

Petrography

Mylonitic rocks from the bed of the Swan River 0.8 km SSE of Mt Mambup range from mylonite to blastomylonite. They are greenish grey (5GY6/1-5G6/1) to medium bluish grey (5B5/1) with rough to subconchoidal fracture, and some are strongly foliated. Here and there folia are displaced a few millimetres by faults, and are cut by thin quartz veins. The mylonites contain elongate, aligned quartz and feldspar porphyroclasts set in a poorly foliated groundmass mainly of very finely divided silica and epidote. The quartz porphyroclasts show undulose extinction or have been converted into numerous subgrains. Some rocks have a granular groundmass with a mean grainsize of 0.06 mm, evidently due to recrystallization, and are best called blastomylonite.

At Walyunga, the mylonitic rock is a flinty, almost aphanitic, pale greenish yellow to pale olive (10Y8/2-10Y6/2) rock that is practically massive and breaks with subconchoidal fracture. Porphyroclasts of quartz and subordinate sodic plagioclase occur in a groundmass of epidote granules having a mean grainsize of about 5 μm, and a little silica. A few porphyroblasts of epidote attain a diameter of 100 μm. The quartz porphyroclasts are strained or finely granulated, whereas the feldspar has survived well except for local displacement of twin lamellae by microfaults. The porphyroclasts compose only about 5% of the rock and tend to have a common lineation. The rock is cut by veins of microcrystalline quartz that are generally less than 0.5 mm thick. The veins have many orientations, but there is commonly one set more or less parallel to the orientation of the porphyroclasts, and two other sets at about 60° to that direction. Some veins pinch and swell, others consist of narrow lenses arranged *en echelon*. This rock is difficult to fit precisely into existing classifications, but is evidently an altered mylonite or cataclasite.

Comparison with flakes.

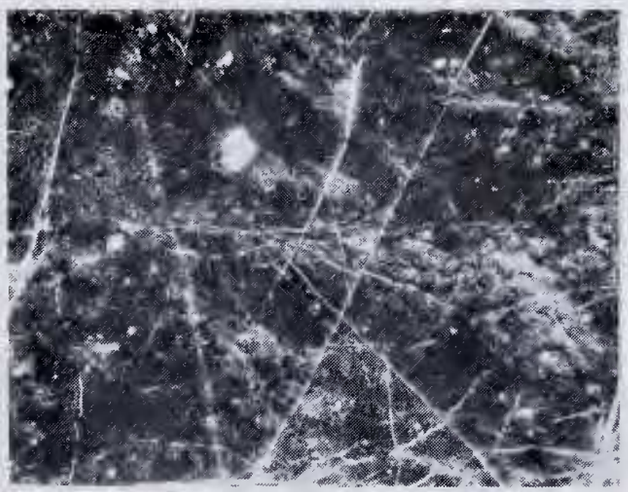
The cherty epidote-bearing flakes of the Perth Basin, and of the Walyunga area just outside its eastern margin, are very like the mylonitic rocks in colour, fracture, mineralogy and texture. Thin sections of flakes and mylonitic rock are practically indistinguishable (see Fig. 2 A-F).

Discussion

The pronounced lithological similarity between the cherty epidote-bearing flakes and mylonitic rocks of the Walyunga area provides a clear indication of their mylonitic origin. As noted carlier (Glover 1975), the textures of some flakes resemble those of metasedimentary and meta-

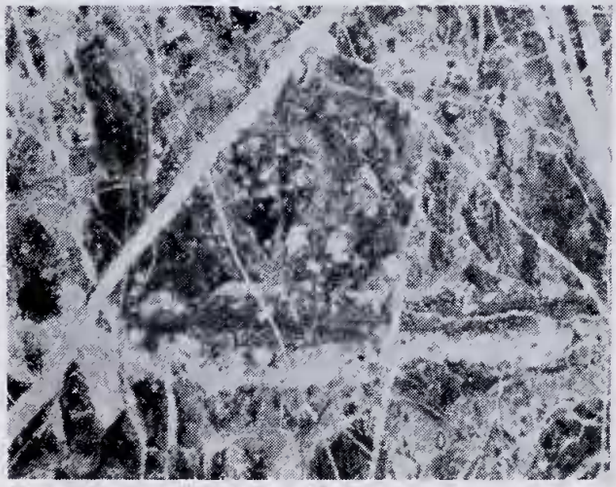
Figure 2.—A.—Mylonitic rock from outcrop at Walyunga. White porphyroclasts are strained to finely granulated quartz, groundmass is finely granular epidote with a little silica. Veins are quartz. University No. 74903. Width of field 4.75 mm. Plane polarized light. B.—Artifact from Bell Bros Sandpit, Gnangara Road, Grid Ref. 39730675 (locality 16). White porphyroclasts are finely granulated quartz, groundmass is finely granulated epidote and a little silica. Veins are quartz. University No. 74737. Width of field 4.75 mm. Plane polarized light. C.—Mylonite from outcrop in bed of Swan River, 0.8 km SSE of Mt Mambup. White porphyroclasts are strained and granulated quartz with subordinate sodic plagioclase, groundmass is a fine mixture of silica and epidote. Veins are quartz. University No. 74900. Width of field 4.75 mm. Plane polarized light. D.—Artifact from sand, Kewdale, Grid Ref. 39550449 (Locality 27). White porphyroclasts are strained and granulated quartz, groundmass is a fine mixture of silica and epidote. Veins are quartz. University No. 74617. Width of field 4.75 mm. Plane polarized light. E.—Mylonite from outcrop in bed of Swan River 0.8 km SSE of Mt Mambup. White porphyroclasts are strained and granulated quartz, groundmass is a fine mixture of silica and epidote with a little fine white mica parallel to the foliation. Chlorite is also locally present. University No. 74901. Width of field 4.75 mm. Plane polarized light. F.—Artifact from sandy area, Walyunga, Grid Reference 40640743 (locality 11). White porphyroclasts are strained and granulated quartz, groundmass is a fine mixture of silica and epidote with a little fine white mica parallel to the foliation. University No. 74904. Width of field 4.75 mm. Plane polarized light.

A



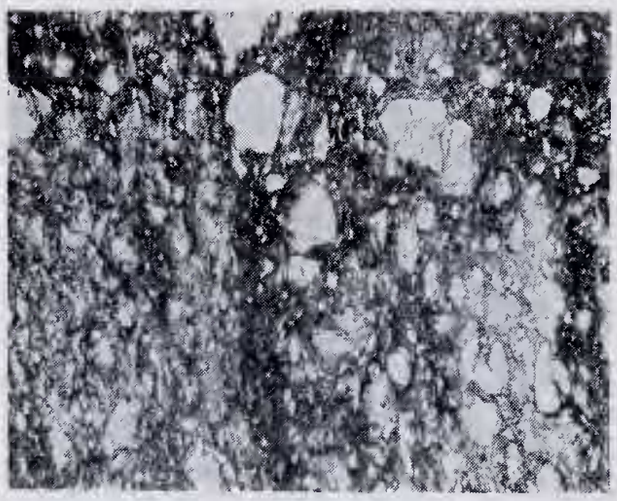
B

C



D

E



F

volcanic rocks, but it can scarcely be doubted that these textures arise from the cataclasis and neomineralization of Archaean granitoid. The tendency for the mylonitic flakes in areas of the Perth Basin north of the Swan River to increase in frequency toward Gingin and Walyunga shows that the sources could have been in mylonitic rocks of the Walyunga area, or in counterparts along the strike of the Darling Fault Zone towards Mogumber. There may have been other sources of mylonitic rock for sites south of the Swan River.

Acknowledgements.—Helpful discussions were had with Mrs. S. J. Hallam and Mr. R. H. Pearce of the Department of Anthropology, University of Western Australia, Dr. R. Marston, Geology Department, University of Western Australia, and Dr. S. A. Wilde of the Geological Survey of Western Australia.

References

Barbetti, M., and Allen, H. (1972).—Prehistoric man at Lake Mungo, Australia, by 32 000 years B.P. *Nature, Lond.*, 240 (5375), 46-48.

Bell, T. H., and Etheridge, M. A. (1973).—Microstructure of mylonites and their descriptive terminology. *Lithos*, 6, 337-348.

Christie, J. M. (1960).—Mylonitic rocks of the Moine Thrust-Zone in the Assynt Region, North-West Scotland. *Trans Edinburgh Geol. Soc.*, 18, 79-93.

Dortch, C. E., and Merrilees, D. (1973).—Human occupation of Devil's Lair, Western Australia, during the Pleistocene. *Archaeol. Phys. Anthrop. in Oceania*, 8, 89-115.

Glover, J. E. (1975).—The petrology and probable stratigraphic significance of Aboriginal artifacts from part of southwestern Australia. *J. R. Soc. West. Aust.* 58, 75-85.

Hallam, Sylvia J. (1972).—An archaeological survey of the Perth area, Western Australia: a progress report on art and artefacts, dates and demography. *Aust Inst. Aboriginal Studies Newsletter*, 3 (5), 11-19.

Hallam, Sylvia J. (1974).—Excavations in the Orchestra Shell Cave, Wanneroo, Western Australia. Part 1. Ethnographic and environmental background. *Archaeology and Physical Anthropology in Oceania*, 9 (1), 66-84.

Joplin, G. A. (1968).—*A Petrography of Australian Metamorphic Rocks.* Angus & Robertson, Sydney.

Lapworth, C. (1885).—The Highland controversy in British geology: its causes, course and consequences. *Nature, Lond.* 32, 558-559.

Reed, J. J. (1964).—Mylonites, cataclasites, and associated rocks along the Alpine Fault, South Island, New Zealand. *N.Z. Jl. Geol. Geophys*, 7, 645-684.

Rock-color Chart Committee (1963).—*Rock-color Chart.* Geol. Soc. Am., New York.

Spry, A. (1969).—*Metamorphic Textures.* Pergamon, Oxford.

Wilde, S. A. (1974).—Explanatory notes on the Archaean rocks of the Perth 1:250 000 geological sheet, Western Australia. *Rec. Geol. Surv. West. Aust.* 1974/15 (unpubl.)

Zeck, H. P. (1974).—Cataclastites, hemiclastites, holoclastites, blasto-ditto, and myloblastites—cataclastic rocks. *Am. J. Sci.* 274, 1064-1073.